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(71) Applicant
Screening Consultants Limited

(Incorporated in the Channel Islands)

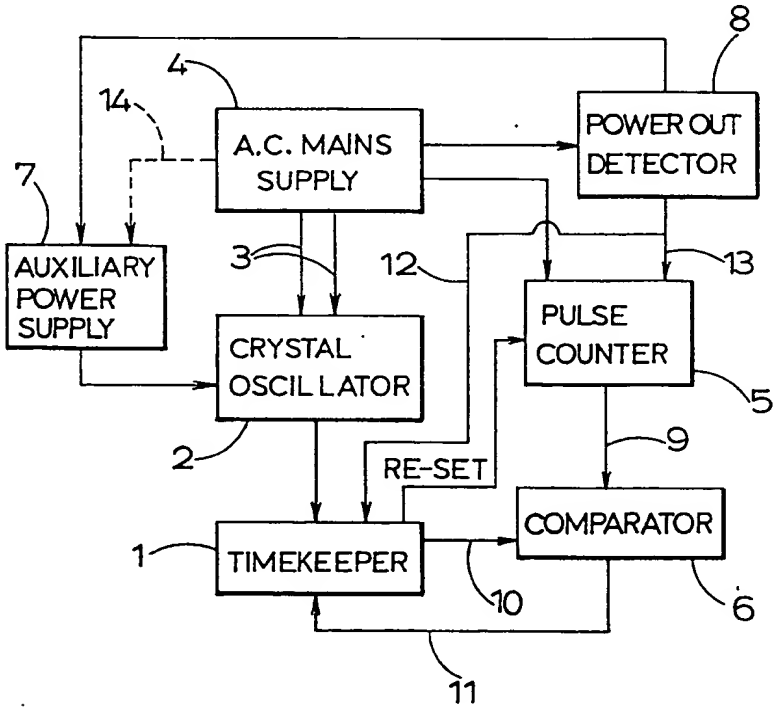
Oak Walk, St. Peter, Jersey, Channel Islands

(72) Inventor
Ian Clive Bratt

(74) Agent and/or Address for Service
Barker Brettell & Duncan
138 Hagley Road, Edgbaston, Birmingham, B16 9PW,
United Kingdom

(54) Crystal oscillator-controlled clocks

(57) To maintain its accuracy over a relatively long period of time a crystal oscillator-controlled real time clock which connects to an a.c. mains electricity supply has a pulse counter 5 for counting pulses of the supply, and a comparator 6 which adjusts the timekeeper 1 of the clock when a predetermined time period has elapsed and according to the number of pulses counted during that period. Comparison of the time value may be made, for example, once every 24 hours. The clock may be used in a programmable timeswitch designed to be used in a system for operating a "deferable load programme" in which the supply of electricity to a plurality of different installations is controlled by timeswitches in accordance with a predetermined yearly programme. An auxiliary power supply 7 powers the crystal oscillator 9 when the mains electricity supply fails. The pulse counter 5 is reset when the supply has been interrupted.



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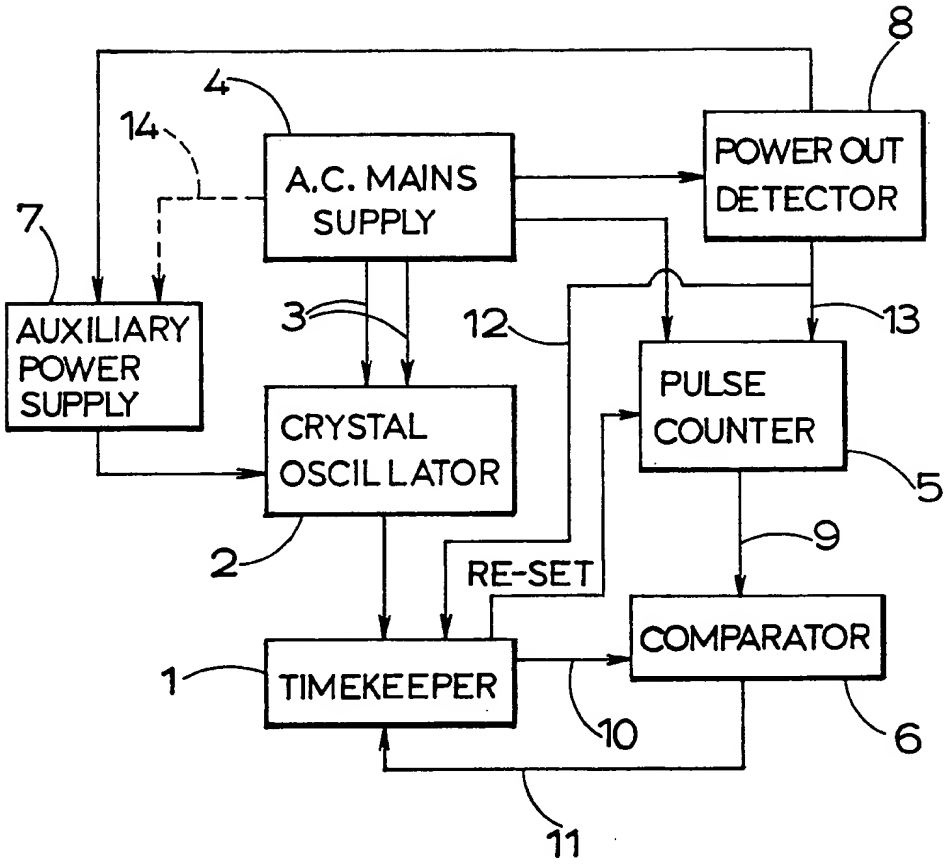
8
4
14
A.C. MAINS SUPPLY
POWER OUT DETECTOR
7
AUXILIARY POWER SUPPLY
3
12
13
PULSE COUNTER
CRYSTAL OSCILLATOR
5
9
2
RE-SET
COMPARATOR
1
TIMEKEEPER
10
6
11

CRYSTAL OSCILLATOR-CONTROLLED CLOCKS

This invention relates to crystal oscillator-controlled clocks.

A real-time clock controlled by a crystal oscillator keeps time in accordance with regular high frequency vibrations of a piezo-electric crystal, such as quartz, and is very accurate over a short period of time. However, in some crystal oscillators, a very slight variation in the frequency of the vibrations of the crystal from its theoretical value can lead over a longer period of time to a larger cumulative error in the time kept by the real-time clock, sometimes as large as 10 minutes over twelve months. An error of this magnitude is undesirable in devices of the kind which incorporate real-time clocks and which are intended to operate for long periods of time (e.g. several months or more) without requiring adjustment.

One such device of this kind, a programmable timeswitch for controlling the supply of electricity to electrical apparatus in accordance with a predetermined yearly programme, is disclosed in British Patent Application No. GB-A-2 202 973. In that timeswitch a real-time clock is controlled by a crystal oscillator powered from a mains alternating current (a.c.) electricity supply and a separate auxiliary power supply may also be provided to keep the oscillator and clock running during periods of failure of the mains supply.

It is an aim of the present invention to maintain, over a relatively long period of time, the accuracy of such a crystal oscillator-controlled real-time clock.

According to the present invention there is provided a crystal oscillator-controlled real time clock comprising a timekeeper controlled by a crystal oscillator, means for connecting the real-time clock to an a.c. mains supply of electricity, a pulse counter for counting pulses of an a.c. mains supply and adjustment means capable of adjusting the timekeeper when a predetermined time period has elapsed and in accordance with the number of pulses counted during that period.

Preferably, a time value given by the timekeeper is compared with a time value corresponding to the number of pulses counted within the predetermined period, and the time kept by the timekeeper is adjusted when the time values differ.

The comparison between the time values may take place after any suitable predetermined time period which may be determined either by the timekeeper itself or by the pulse count of the mains supply. In a preferred embodiment the comparison is arranged to take place once every 24 hours.

A time value obtained from a pulse count of an a.c. mains supply (50Hz in the U.K.; 60Hz in the U.S.A.) over a relatively short period of time (e.g. less than 12 hours) is generally not as accurate as the time value obtained from a crystal oscillator over the same period because of periods of peak load demand and low load demand, but over longer periods of time (e.g. several months) a mains supply can provide more accurate time values than a crystal oscillator in which a cumulative error occurs. Indeed time values calculated from mains electricity supplies of 50Hz and 60Hz have been found to be remarkably accurate

over a twelve month period having errors of less than one second.

The real-time clock of the present invention is particularly suitable for use in a programmable timeswitch of the kind disclosed in GB-A-2 202 973 which is designed to be used in a system for operating a "deferable load programme" in which the supply of electricity to a plurality of different installations is controlled by a plurality of timeswitches in accordance with a predetermined yearly programme. In such a system, it is desirable for the real-time clocks of the timeswitch to maintain a high degree of accuracy over long periods of time, for instance periods of a year and above.

Preferably, and in particular when a real-time clock in accordance with the present invention is used in a system as described above, an auxiliary power supply is provided which is arranged to power the crystal oscillator when the mains a.c. power supply fails. Failure of the mains power supply may be conveniently detected by a "power-out" detector, and the pulse counter is preferably arranged to be reset at the end of a predetermined time period which includes a period of power interruption.

A real-time clock in accordance with the present invention will now be described, by way of example only, with reference to the accompanying schematic block diagram.

The real-time clock shown in the diagram comprises a time-keeper 1 controlled by a crystal oscillator 2 which is connected by means of suitable connecting leads 3 to an alternating current (a.c.) mains supply 4

(typically 50Hz in the U.K. and 60Hz in the U.S.A.). The real-time clock also includes a pulse counter 5 connected to the mains supply 4, a comparator 6 connected to the timekeeper 1 and the pulse counter 5, an auxiliary power supply 7 for the crystal oscillator 2 and a "power out" detector 8 which detects failure of the mains supply 4.

In operation, the a.c. from the mains supply 4 is continually monitored by the pulse counter 5 which counts the pulses or cycles of the a.c. mains supply 4. When a predetermined number of pulses (or cycles) have been counted (e.g. a number indicating that 24 hours has elapsed) or when a predetermined time period (e.g. 24 hours) determined by the timekeeper itself has elapsed, the pulse counter 5 is arranged to send a first time value signal via line 9 to the comparator 6 which compares that time value signal with a second time value signal received from the timekeeper 1 via line 10, and the pulse counter 5 is reset to zero so that it can start another pulse count.

If the first and second time value signals differ from each other, the comparator 6 sends an adjustment signal via line 11 to the timekeeper 1 which adjusts the time of the timekeeper 1 to conform with the first time value obtained from the pulse counter 5. This procedure is repeated at regular intervals at the end of each predetermined time period determined either by the predetermined number of pulses counted by the pulse counter 5 or by the timekeeper 1 itself, e.g. once every 24 hours, and so the accuracy of the time kept by the real time clock is maintained by the frequency of the a.c. mains supply.

In the event of failure of the a.c. mains supply 4 which is detected by the "power out" detector 8, the auxiliary power supply 7 (which may conveniently comprise at least one Nickel-Cadmium battery) is automatically switched on to power the crystal oscillator 2 thereby keeping the timekeeper 1 running during interruption of the mains power supply. The pulse counter 5 will stop counting pulses upon failure of the mains supply. Also, the "power-out" detector 8 sends power interruption signals via lines 12 and 13 to the timekeeper 1 and to the pulse counter 5 which, at the end of the predetermined 24 hour time period, prevent the comparator 6 from carrying out its comparison of the time values and thus from adjusting the timekeeper 1 in accordance with a spurious time value from the pulse connector 13. Instead, after receiving a power interruption signal from the "power out" detector 8, the timekeeper 1 sends a reset signal via line 15 to the pulse counter 5 at the end of the predetermined 24 hour time period so that the pulse count is restarted. Thus, under normal circumstances the pulse counter adjusts the crystal oscillator-controlled timekeeper at the end of each predetermined 24 hour period, but in the event of failure of the mains supply, the timekeeper resets the pulse counter at the end of the predetermined time period so that the timekeeper and pulse counter are synchronised every 24 hours. The real-time clock is therefore able to operate continually throughout periods of interruption of the mains supply and its accuracy is monitored and adjusted (except when there is an interruption of the mains a.c. supply) once every 24 hours in accordance with the frequency of the mains a.c. supply which, over long periods of time, e.g. twelve months or more, generally produces a smaller

error than a typical cumulative error produced by a crystal oscillator alone.

The comparison between the first time value on line 9 from the pulse counter 5 and the second time value on line 10 from the crystal oscillator-controlled timekeeper 1 may be made every 24 hours at any time during the day or night. When the real-time clock is included in a programmable timeswitch of the kind disclosed in GB-A-2 202 973, this comparison is preferably made at a time when no switching takes place, for instance at 4.00 a.m.

The auxiliary power supply 7 is preferably able to run the crystal oscillator 2 and the timekeeper 1 for a period of at least seven days when failure of the mains supply 4 occurs and is preferably rechargeable from the mains supply 4 (e.g. by being trickle charged via broken line 14) so that the real time clock can operate for periods well in excess of one year, provided that no periods of power failure exceeding seven days occur.

CLAIMS

1. A crystal oscillator-controlled real time clock comprising a timekeeper controlled by a crystal oscillator, means for connecting the real-time clock to an a.c. mains supply of electricity, a pulse counter for counting pulses of an a.c. mains supply and adjustment means capable of adjusting the timekeeper when a predetermined time period has elapsed and in accordance with the number of pulses counted during that period.

2. A crystal oscillator-controlled real time clock as claimed in claim 1 in which a time value given by the timekeeper is compared with a comparative time value corresponding to the number of pulses counted within the predetermined time period, and the time value kept by the timekeeper is adjusted when it differs from the comparative time value.

3. A crystal oscillator-controlled real time clock as claimed in claim 2 in which the comparison of the timekeeper's time value with the comparative time value is determined by the timekeeper.

4. A crystal oscillator-controlled real time clock as claimed in claim 2 in which the comparison of the timekeeper's time value with the comparative time value is determined by the pulse count at the pulse counter.

5. A crystal oscillator-controlled real time clock as claimed in claim 2 in which the comparison of the

timekeeper's time value with the comparative time value is taken once every 24 hours.

6. A crystal oscillator-controlled real time clock as claimed in any preceding claim including auxiliary power supply means adapted to power the crystal oscillator automatically in the event that the a.c. mains supply fails.

7. A crystal oscillator-controlled real time clock as claimed in claim 6 including a "power-out" detector adapted to detect failure of the a.c. mains supply, and in which the pulse counter is adapted to be reset at the end of a predetermined time period which includes a period of time interruption.

8. A crystal oscillator-controlled real time clock as claimed in claim 6 including a "power-out" detector adapted to detect failure of the a.c. mains supply, and in which the adjustment means is a comparator, the "power-out" detector sends power interruption signals to the timekeeper and to the pulse counter which, at the end of the predetermined time period, prevent the comparator from carrying out a comparison of a time value given by the timekeeper with a comparative time value corresponding to the number of pulses counted within the predetermined time period and thus from adjusting the timekeeper, and the timekeeper, after receiving a power interruption signal from the "power-out" detector, sends a reset signal to the pulse counter at the end of the predetermined time period which restarts the pulse count.

9. A crystal oscillator-controlled real time clock as claimed in claim 6 in which the auxiliary power supply

means is arranged to be recharged from the a.c. mains supply.

10. A programmable timeswitch including a crystal oscillator-controlled real time clock as claimed in any preceding claim.

11. A system for controlling the supply of electricity to electrical apparatus at a plurality of installations comprising a master console and a plurality of programmable timeswitches each of which is associated with an individual one of the installations, each of the timeswitches comprising a crystal oscillator-controlled real time clock as claimed in any of claims 1 to 9, programmable memory means for storing a predetermined yearly programme for the supply of electricity to electrical apparatus during a calendar year, coded connections through which said programme can be entered into the memory means, switching means capable of varying the supply of electricity to electrical apparatus and control means which, in response to signals from the timekeeper of the real time clock, is operable to control the switching means to vary the supply of electricity to the apparatus in accordance with the predetermined yearly programme, and the memory means of each of the timeswitches having been programmed from the master console via the coded connections with the yearly programme and being arranged to control the supply of electricity to the electrical apparatus at each of the individual installations in accordance with the predetermined yearly programme.

12. A crystal oscillator-controlled real time clock substantially as described herein with reference to the accompanying drawing.

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